

Serial No. 10/622,100

February 14, 2005

Reply to the Office Action dated November 18, 2004

Page 2 of 22

AMENDMENTS TO THE SPECIFICATION:

Please REPLACE the paragraph no. [0037] of the Specification with the following amended paragraph:

[0037] The big end 104 further includes ~~and~~ an outer surface 113 that generally includes any surface of the big end 104 that is not the wall of the bolt holes 112 or the wall of the crankpin hole 110 (e.g., any outward facing surface of the big end 104)). A dividing plane 118, along which the big end will be split in Step 34, divides the big end 104 into a rod part ~~114~~ 116 disposed on one side of the dividing plane 118 and a cap part 120 disposed on the other side of the dividing plane 118. The dividing plane 118 extends through both the crankpin and bolt holes 110, 112, and in the illustrated embodiment, the dividing plane contains the axis of the crankpin hole 110. Accordingly, at the blank stage, the rod part 116 and the cap part 120 are initially formed as a single piece and the crankpin hole 110 is preferably disposed at least near, if not at the center of the big end 104.

Please REPLACE the paragraphs nos. [0039] and [0040] of the Specification with the following amended paragraphs:

[0039] The fracture starting grooves 122 are disposed along the wall of the crankpin hole 110 and lie generally in or are generally centered about the dividing plane 118. The fracture starting grooves 122 aid in forming a stress riser during fracture splitting of the rod and cap parts ~~114~~ 116, 120 (Step 34).

[0040] As seen in FIGURE 2, the shoulder parts 124 extend from the rod 102. The shoulder parts 124 are respectively bored with the bolt holes 112. Each bolt hole 112 preferably includes a first section suitably sized to be tapped with internal threads and a

Serial No. 10/622,100
February 14, 2005
Reply to the Office Action dated November 18, 2004
Page 3 of 22

second section that has a larger diameter size to receive freely the bolt that will be used to join together the rod and cap parts ~~114~~ 116, 120. The first section of each hole 112 lies entirely to one side of the dividing plane 118.

Please REPLACE the paragraphs nos. [0053] and [0054] of the Specification with the following amended paragraphs:

[0053] An exemplifying procedure for fracture splitting the big end 104 into the rod part 116 and the cap part 120 is described with reference to FIGURES 5 and 6. The method herein ~~described~~ described is illustrative only and other methods of fracture splitting the big end 104 into the rod part 116 and the cap part 120 are consistent with embodiments of the present invention. The connecting rod 100 is placed on top of a surface plate 143 and two sliders 144 are inserted in the crankpin hole 110 such that they are diametrically movable. A wedge 148 is disposed between the two sliders 144 such that each of the wedge faces mate with a similarly angled face on each of the two sliders 144, as best seen in FIGURE 6. A force F is applied to the top of the wedge 148, which produces a separating force on the rod and cap parts ~~114~~ 116, 120 as the wedge 148 is driven into the two sliders 144.

[0054] As the wedge 148 is driven between the sliders 144, stresses are produced along the wall of the crankpin hole 110. The brittleness of the hardened material in the thin wall region 128 between the crankpin and bolt holes 110, 112 combined with the use of the fracture starting grooves 122 produce a condition in which a relatively small amount of strain is needed to initiate a fracture at the region 128. Therefore, the smallest wall thickness W1 in the vicinity of each of the bolt holes 112 serves as the starting point of fracture separation. The application of the separating force generally along the dividing plane 118 produces a higher stress in the vicinity of the region 128 than the stress produced in the vicinity of the unhardened material (core material).

Serial No. 10/622,100
February 14, 2005
Reply to the Office Action dated November 18, 2004
Page 4 of 22

Consequently the region 128 acts as a stress raiser to initiate fracture from this point on each side of the crankpin hole 110. As a result of the single fracture starting points corresponding to each of the bolt holes 112, the rod and cap parts ~~114~~ 116, 120 have fracture surfaces 138, 140 that are normally free from double fractures. This process also involves a simpler jig, which thereby can reduce production costs in comparison to the prior fracturing methods described above.

Please REPLACE the paragraphs nos. [0056] and [0057] of the Specification with the following amended paragraphs:

[0056] With reference to FIGURES 9 and 10, in certain embodiments, the rod part fracture surface 138 and the cap part fracture surface 140 each comprise a grain boundary fracture surface and an elongation fracture surface. The grain boundary fracture surface includes portions of the fracture surfaces 138, 140 that are generally hardened (e.g., within the hardened surface layer 126). The elongation fracture surface comprises portions of the fracture surfaces 138, 140 that are generally unhardened (e.g., within the interior portion 130 of the rod and cap parts ~~114~~ 116, 120 prior to fracture splitting). The micrographs shown in FIGURES 9 and 10 are of a fracture split surface for a connecting rod 100 produced according to the illustrated method 20. In FIGURE 9, which shows a grain boundary fracture surface comprising generally hardened material, the grains lie along the grain boundary, without elongating at right angles to the fracture surface. Such grain structure produces a fracture surface that is substantially flat.

[0057] In FIGURE 10, which shows an elongation fracture surface comprising generally unhardened material, the grains are elongate and separate generally at right angles to the fracture surface, forming a large number of microscopic irregularities. These irregularities in the interior portions of the rod and cap part fracture surfaces 138, 140

Serial No. 10/622,100
February 14, 2005
Reply to the Office Action dated November 18, 2004
Page 5 of 22

allow the rod and cap parts ~~114~~ 116, 120 to be accurately repositioned and aligned to each other when they are subsequently reconnected. In addition, these irregularities help to prevent lateral motion between the rod and cap parts ~~114~~ 116, 120 after attachment to a crankshaft.

Please REPLACE the paragraph no. [0059] of the Specification with the following amended paragraph:

[0059] The preferred mix of these two fracture surface types is achieved by controlling the depth T of the hardened surface layer 126. The depth T of the hardened surface layer 126 preferably is selected so as to produce a ratio of the elongate fracture surface area to the sum of the elongate fracture surface area and the grain boundary fracture surface area, herein referred to as the "elongation fracture ratio", that is within a predetermined range. As understood from FIGURE 12, the predetermined range of the elongation fracture ratio is preferably between about 0.3 and about 0.7, more preferably is between about 0.4 and about 0.6, and most preferably about 0.5. An improved degree of circularity is obtained upon reassembly of the rod and cap parts ~~114~~ 116, 120 when the elongation fracture ratio is within one of the preferred ranges.

Please REPLACE the paragraphs nos. [0062]-[0064] of the Specification with the following amended paragraphs:

[0062] With reference now to FIGURE 13, the method 20 can further comprise the Step 38 of assembling the rod and cap parts ~~114~~ 116, 120 of the big end 104 in preparation for final machining of the connecting rod 100 in Step 40. The rod and cap parts ~~114~~ 116, 120 may be positioned relative to each other using their respective elongation fracture surfaces and tightened together using bolts 148 threaded into the threaded sections 132 of the bolt holes 112. As each of the bolts 148 is tightened, the elongation fracture

Serial No. 10/622,100

February 14, 2005

Reply to the Office Action dated November 18, 2004

Page 6 of 22

surfaces of the rod and cap parts ~~114~~ 116, 120 are crushed to form mating surfaces of irregular shape. During subsequent reassembly, such as when the connecting rod is attached to the crankshaft, the mating surfaces of the rod and cap parts ~~114~~ 116, 120 register to one another, thus maintaining accurate alignment. Final machining (Step 40) is performed while the rod and cap parts ~~114~~ 116, 120 are assembled to form the connecting rod 100.

[0063] Once fabricated, the connecting rod 100 ~~comprising~~ includes the small end 108, the big end 104, and the rod 102. The big end 104 includes the rod part ~~114~~ 116 and the cap part 120, which is separable from the rod part ~~114~~ 116. The rod and cap parts ~~114~~ 116, 120 have mating faces comprising an outer perimeter 152 and a void (e.g., the bolt hole 112 in the illustrated embodiment), a first surface comprising material that is hardened (e.g., the hardened surface 141), and a second surface comprising material that is generally unhardened (e.g., the unhardened surface 142). The rod and cap parts ~~114~~ 116, 120 have mating faces and further comprise a portion between the outer perimeter and the void (e.g., the region 128 in the illustrated embodiment) that comprises hardened material.

[0064] When assembled with a crankshaft (Step 44), the rod and cap parts ~~114~~ 116, 120 are separated by removing the bolts 148. Each part ~~114~~ 116, 120 is placed about a crankpin of the crankshaft and aligned with each other so that the crankpin concentrically fits within the resulting crankpin hole 110. The bolts are threaded into the bolt holes 112, to reattach together the rod and cap parts ~~114~~ 116, 120.

Serial No. 10/622,100
February 14, 2005
Reply to the Office Action dated November 18, 2004
Page 7 of 22

Please REPLACE the Abstract of the Disclosure with the following amended Abstract of the Disclosure:

A connecting rod is formed using a method that ~~comprising~~includes providing a connecting rod blank having. The connecting rod blank has a rod section disposed between a big end and a small end. The big end has a first hole generally sized to receive a crankpin of a crankshaft and at least one second hole generally sized to receive a bolt, wherein the axes of the first and second holes are generally normal to each other. The big end of the connecting rod has a dividing plane that extends through both the first and second holes. The connecting rod blank is processed by hardening at least the big end to a sufficient depth such that a first region of the big end lying between the first and second holes at the dividing plane is hardened, while leaving a substantial second region of the big end at the dividing plane generally unhardened. The connecting rod blank is further processed by splitting the big end along the dividing plane to produce a rod part fracture surface and a cap part fracture surface.